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The Naval Space Surveillance System was developed by the Naval Research Laboratory (NRL) during the period 1958 to 1964. This system was necessary to satisfy the needs of the U.S. Government's desire to detect nonradiating space objects passing over the continental United States (CONUS). This system has been operational since 1960 and is the only Navy system contributing to the Space Detection and Tracking System operated by the Space Defense Center, North American Aerospace Defense Command. This system, with no prior information, detects all objects in Earth's orbit passing over CONUS and computes the orbital elements of these objects.

This report describes the design of the data communications system that was developed as part of the modernization program for improving the performance of the original Naval Space Surveillance Receiver Systems. Salient aspects of the design include increased data throughput, failure-recovery transmission modes,

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18. SUBJECT TERMS

Data communication interface
NAVCOM buffers
Test and control fields
Data transmission protocol
Transmission medium
Transmission rate
Noise power budget

19. ABSTRACT (Continued)

and message formatting characterization to satisfy the special requirements for system operation at Naval Space Surveillance Headquarters. The design also emphasized an abundant margin of data space for the control and text fields that were nearly exhausted at the completion of the developmental tests.

NRL Report 8910

Naval Space Surveillance Modernized Receiver System

Vol. 6—Data Communications Subsystem

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Space Applications Branch
Space Systems and Technology Division

August 14, 1985

NAVAL RESEARCH LABORATORY
Washington, D.C.

CONTENTS

NAVAL SPACE SURVEILLANCE MODERNIZED RECEIVER SYSTEM

Vol. 6—Data Communications Subsystem

INTRODUCTION

This is the sixth and final volume in a series which describes the Naval Research Laboratory's (NRL's) Naval Space Surveillance System (NAVSPASUR) Modernized Receiver System (MRS).

NAVSPASUR was developed by NRL in the period 1958 to 1964 for the detection of nonradiating space objects objects passing over the continental United States (CONUS). The system has been operational since 1960 and is the only Navy system contributing to the Space Detection and Tracking System (SPADATS) operated by the Space Defense Center, North American Aerospace Defense Command (NORAD). The system is responsible to the Chief of Naval Operations for support to the operating naval forces and is under the operational control of the Commander-in-Chief of NORAD.

The function of the system is to detect, with no prior information, all objects in Earth-orbit passing over CONUS, and to compute orbital elements of these objects. Once detected, the objects' ephemerides may be computed with sufficient accuracy to enable their future positions over any part of Earth to be calculated for such purposes as are necessary to maintain a continuous space defense posture. The primary method of supporting the space defense posture is the maintenance of a catalog of all space objects. This means of operation is necessary due to the limited coverage of national space assets, the expanding number of space objects, and the necessity of distinguishing between operational payloads and space debris.

The Space Defense Center specifically tasks NAVSPASUR to provide the following: detection information on new satellites, satellite ephemeris information for the space objects catalog, detection of satellite breakups and deep-space launches, alerts against problem satellites, and handoff information for other surveillance or intelligence sensors. This information takes the form of azimuth/elevation measurements from the central system transmitter. The NAVSPASUR system supports naval activities and fleet units by dissemination satellite information directly to naval units as necessary for their operations.

The system is basically a multistatic continuous wave radar, comprised of three transmitting stations and six interspersed receiver stations, all lying on a great circle extending from Fort Stewart, Georgia, to San Diego, California. The station locations, type, and other data are given in Table 1.

Large linear antenna arrays at the transmitter stations form planar fan beams along a great circle. The receiving stations use multiple array interferometers to measure the angle of arrival of signals returned from objects traversing the fan beam. An object is thus detected, and its position of penetration of the beam is determined by multilateration. The orbit of the object is computed from the position and time information obtained from multiple station observation. Objects at altitudes from 139 km (75 nmi) up to 14,000 km (7500 nmi) are routinely detected, and their orbits are computed. The operational longitude spread at 14,000 km is from 80° W to 120° W.

The modernization of the NAVSPASUR system was confined to the replacement of the receiving systems. Other system assets would be considered separately. As a replacement approach, the design

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Table 1 — Station Characteristics

Name/Location	Type	Antenna Array		Alert Antenna (ft)	Transmitter Power (kW)
		No.	Length (ft)		
San Diego/ Chula Vista, CA	Receiver	12	400	1600	
Cila River/ Maricopa, AZ	Gapfiller Transmitter	1	1600	—	45
Elephant Butte/ Truth or Consequences, NM	Receiver	22	1200	Dual 4800	
Lake Kickapoo/ Archer City, TX	Main Transmitter	1	11,760	—	810
Red River/ Lewisville, AR	Receiver	12	400	1600	
Silver Lake/ Greenville, MS	Receiver	12	400	1600	
Jordan Lake/ Wetumpka, AL	Gapfiller Transmitter	1	1032	—	45
Hawkinsville Hawkinsville, GA	Receiver	22	1200	Dual 4800	
Fort Stewart/ Fort Stewart Army Reservation Savannanh, GA	Receiver	12	400	1600	

of the receivers was to employ the latest solid-state technology, incorporate any practical improvements that could be made within the programmed time, and schedule and optimize the system parameters for the current population of objects in orbit. The approach used in the program resulted from an investigation into methods to improve the range capability (or sensitivity) of the system. In that investigation, techniques were examined to increase the capability of the system for quicker response and wider coverage. Those techniques were applied to the design of the MRS to the extent practical within the scope of the program.

MRS uses contemporary digital technology to enhance the maintainability of the receivers, and redundant design to enhance reliability of operation. MRS consists of a central controller and the following six attached subsystems: RF, alert, interferometer, operator's console, interprocessor communication, and data communication. The overall design philosophy is one of total redundancy. One side of the receiver is designated as the primary system and the other as the secondary system. Each side is the mirror image of the other. The only subsystem not fully redundant is the RF subsystem, but it contains spare channels which can be switched in automatically by the central controller.

A functional block diagram of the MRS is shown in Fig. 1. The alert and interferometer subsystems are connected to the antenna arrays through the RF subsystem configured to provide a single

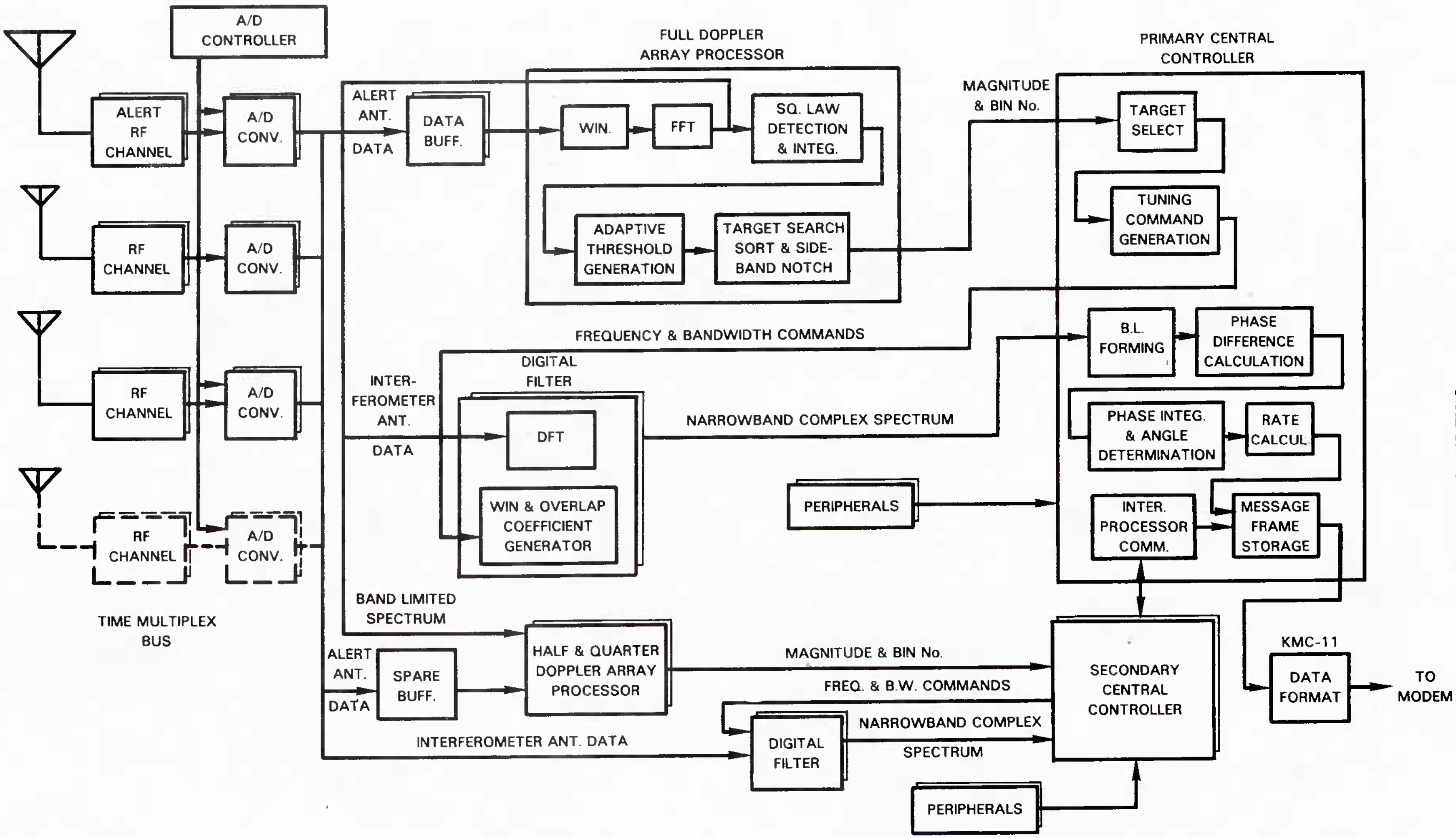

Fig. 1 — Modernized receiver system

channel for each antenna in the array. The alert antenna array contains four antennas or channels of information, which are added together for increased gain. The interferometer antenna array contains 12 antennas or channels of information. At the end of the RF channels, the received data are digitized onto a data bus which feeds both the alert and the interferometer subsystems. There are two data busses, one feeding each system of the receiver. The alert subsystem analyzes the signal spectrum and detects targets. The detected signals are assigned to the interferometer subsystem for data collection and subsequent reduction to the observation parameters by the central controller, and transmitted to NAVSPASUR headquarters over the data lines. The interprocessor communication subsystem allows each receiver to talk to the other and pass target information.

All system data is transferred to the hardware system equipment; either system, "O" or system "1," whichever one is operating in the primary system mode at that particular time. The data are assembled in the primary system data communications subsystem. The data communication subsystem then controls the transfer of the data to NAVSPASUR headquarters in Dahlgren, Virginia, via the data line communications switch. The data communications subsystem is the subject of this report.

DATA COMMUNICATIONS INTERFACE

The data communications interface is illustrated in Fig. 2. The major headquarters equipment is shown in Fig. 3, and the major field station equipment is shown in Fig. 4. A more detailed diagram of the subsystem and its connection with the MRS is shown in Fig. 5. Figure 5 also shows that the subsystem is duplicated in the dual redundant MRS hardware at each field station. The data communication switch and data output point are common to both MRS hardware systems. The switch always connects the data output point to the hardware system which is operating as the primary system.

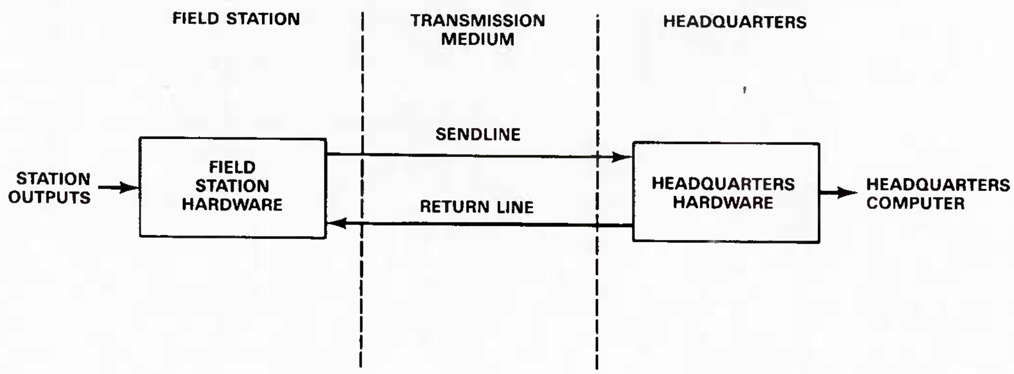

Fig. 2 — Data communication interface

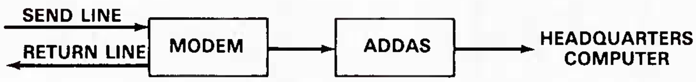

Fig. 3 — Headquarters hardware

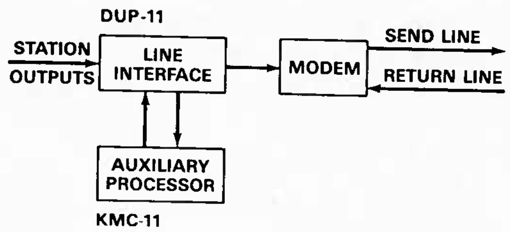

Fig. 4 — Field station hardware

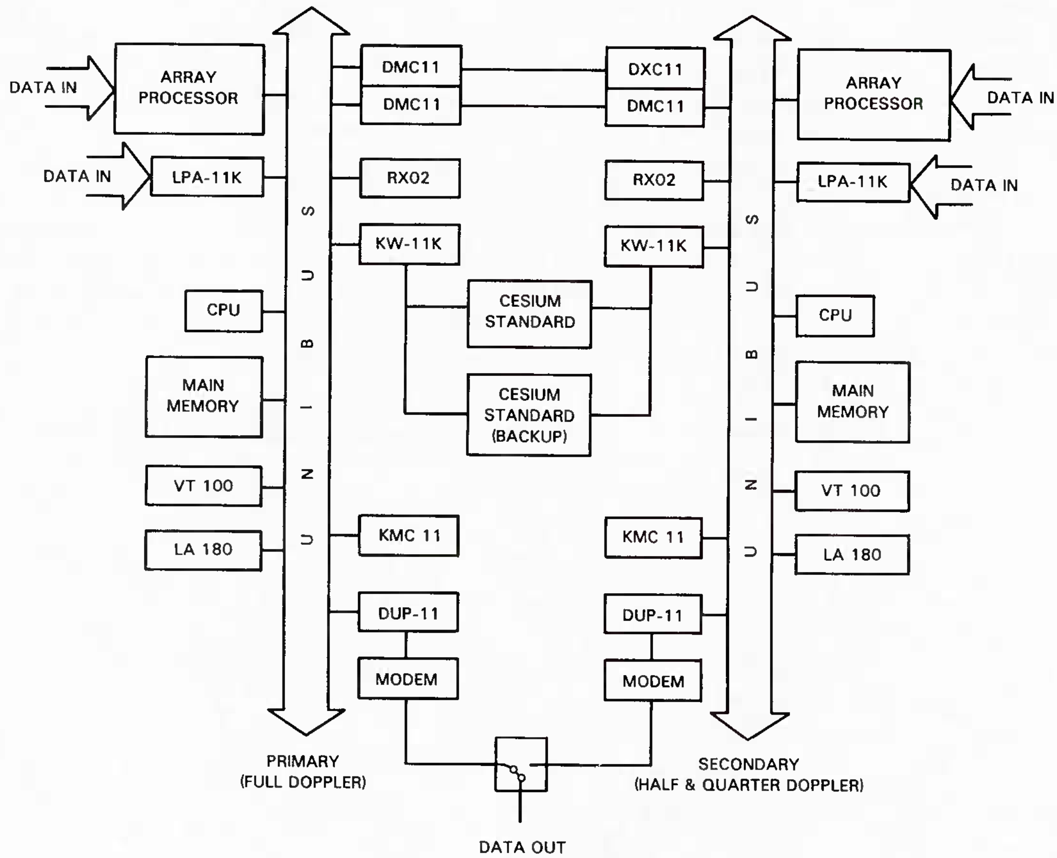

Fig. 5 — Receiver architecture

DATA COLLECTION AND PROCESSING

The MRS hardware illustrated in Fig. 5 consists of two identical sets of equipment, either of which can be operated in a primary or secondary mode. The primary operating mode includes the full doppler (30 kHz) range of the system spectrum. It ensures that minimum operational performance requirements are achieved. The secondary operating mode provides improved resolution and sensitivity for detection of high-altitude objects. In every case, a common RF subsystem provides the drive signals for both sets of hardware. The RF alert antenna signals are processed by the array processor (AP). The doppler and relative amplitude information from the AP are used to tune three sets of interferometer digital filters. The digital filters collect and process signals from the interferometer antenna arrays.

The linear peripheral accelerator (LPA), a multiplexing device, transfers these data to the digital processing equipment. The data are refined by the computer processing unit (CPU) and stored in the NAVSPASUR communication (NAVCOM) buffer section of the primary operating system's main memory. The NAVCOM buffer is the entry point of the text and control fields of the data transmission message frame into the data communications subsystem.

The components essential to the data communications subsystem function are illustrated in Fig. 6. The hardware and software shown in the figure form the operational implementation of the subsystem. In this implementation, the text and control field data of the target message frames are assembled in the communication buffer (NAVCOM). NAVCOM is located in the interstation communications module. Each target frame is stacked in the NAVCOM buffers in the order of occurrence of completion of data processing. When the KMC-11 communications microprocessor has completed the transfer of the last message frame to the modem via the DUP-11 synchronous line driver, it polls the NAVCOM buffer for the next target frame in the stack. If a target frame is available, the KMC-11 transfers the frame by direct memory access (DMA) to its internal data memory registers. The synch byte is added in the first byte location of the message frame. Next, the parity is computed and the parity byte is added to the parity byte location. When the last byte of the last message frame has been transmitted to the data modem by the DUP-11 line interface, the KMC-11 communications processor begins the transfer of the target message frame, a byte at a time, to the DUP-11. At the completion of transmission of two target frames of each set of target data in the NAVCOM buffer, the KMC-11 generates an interrupt to the central controller to signal that the last frame address position in the NAVCOM stack is available for a new target frame. If no target frames are available in the NAVCOM stack, the KMC-11 generates an idle frame for transmission on the data line.

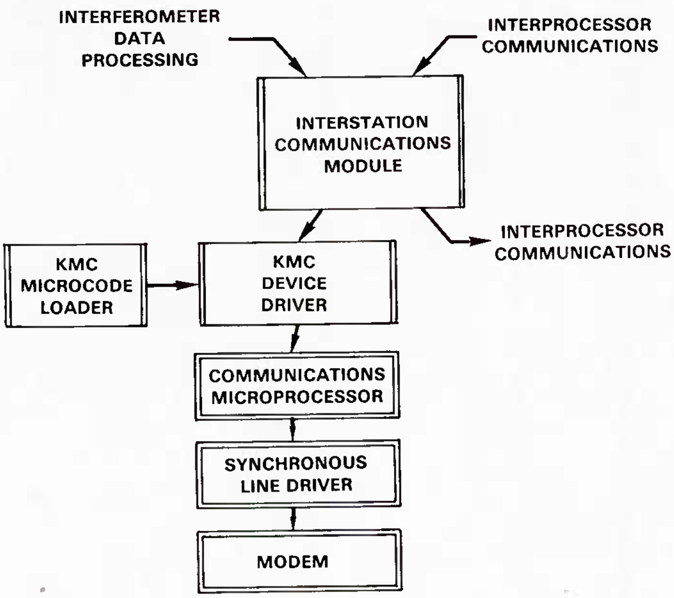

Fig. 6 — Station/headquarters communications

The KMC-11 communications microprocessor possesses special characteristics that make it useful in the data communications application. Although it is designed as a general purpose 16 bit microcomputer, its internal architecture especially suits it to applications for the bilateral conversion of single byte words to double byte words. This architecture, in simplified form, is shown in Fig. 7. It operates in parallel with the host computer. It contains separate data and control memories. Internal registers and busses are byte oriented (8 bits wide). The control and status registers are byte addressable internally and byte and double byte (16 bits wide) addressable externally. When it is used in combination

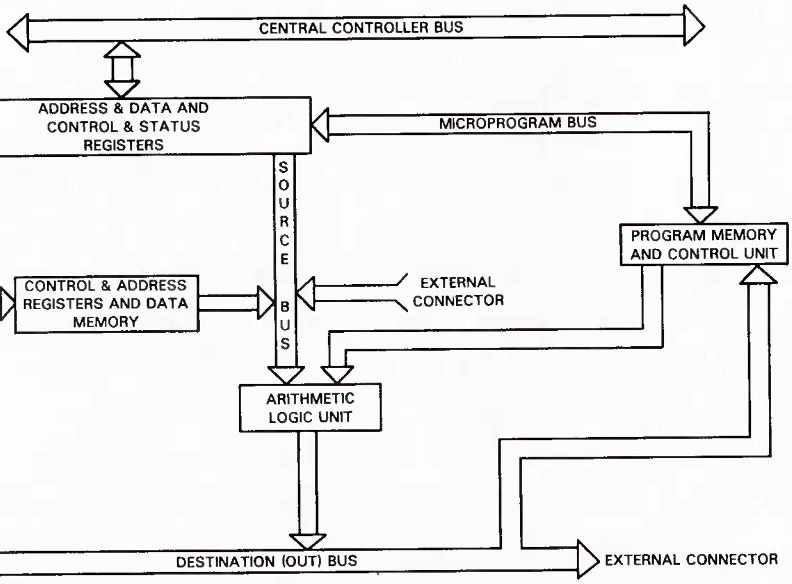

Fig. 7 — KMC-11 communications microprocessor

with the DUP-11 synchronous line interface, a considerable savings in host overhead (reduction in system interrupts) is achieved.

MESSAGE ASSEMBLY AND FORMAT

Message assembly and transmission are performed by the data communication subsystem. The text and control field data from the NAVCOM buffer are assembled into the message format shown in Fig. 8. The auxiliary communication processor prefixes the text and control fields with the message-synchronizing byte and terminates the message with the parity byte. The message illustrated is for a target message frame, the text fields of which contain the data processed for a single satellite by the field station MRS. The definition of the text field data is given in Table 2. Descriptions of the field parameters are listed in Table 3. The bit locations of each type of data are given in Table 4.

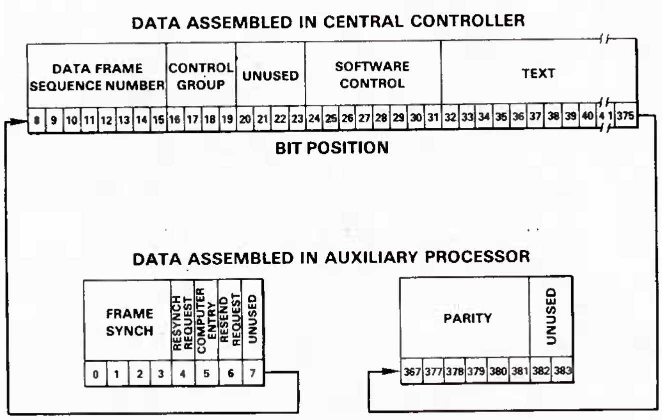

Fig. 8 — Message format

Table 2 - Definition of Test Data Field Terms

Space Angle	Angle of the line of position of a satellite as measured from the field station zenith
Sine (Space Angle)	Slope × Time + Intercept
Slope	Time rate of change of the Sine (Space Angle)
Intercept	Value of the Sine (Space Angle) at the Time Stamp
Time Stamp (Start Time)	Time of initiation of digital filter tuning in the interferometer
Variance	Statistical variation of the data samples from the calculated slope
Frequency	Signal doppler shift of the received signal from the transmitter frequency
Signal Amplitude	Statistical average signal strength of target data collected by the interferometer
E/W	East-West interferometer antenna
N/S	North-South interferometer antenna
CPU	Central controller (PDP-11/60)
Doppler Rate	Rate of change of Doppler frequency
Number of Points	Number of data points used in the measurement

Table 3(a) — Description of Test Data Field for Each Parameter

Field	Number of Bits	Range
Doppler Frequency	24	0 to 32,000 Hz
Doppler Rate	24	0 to 32,000
Doppler Variance	8	1 to 10^{-15}
Number of Points (Doppler)	8	0 to 255
Signal Duration	8	1 to 55 frames
Signal Amplitude	8	−200 to −72 dB
E/W or N/S Slope	24	0 to 16,777,215
E/W or N/S Intercept	24	0 to 16,777,215
E/W or N/S Variance	8	1 to 10^{-15}
Time	20	0 to 600,000 ms
Doppler Region	2	Full = 01, Half = 10, Quarter = 11
CPU	2	CPU A = 00, CPU B = 01

Table 3(b) — Data Field Descriptive Formats

Doppler Frequency:
  [I*2 unsigned integer word (+16,000)]

Range: 0 to 32,000

```
  <-----DF No. --->
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  !   Byte 3       !       Byte 2        !     Byte 1       !
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
MSB
```

  Doppler frequency included in Bytes 1 and 2
  Digital filter number included in Byte 3
  Order of transmission: Byte 1, Byte 2, Byte 3

Doppler Rate:
  [I*2 unsigned integer word (+16,000)]
  Range: 0 to 32,000

Doppler Variance:
  [I*1 unsigned integer 8 bits]
  Contains -log 10 (calculated variance)
  Lower limit of 10^{-15}

Number of Points — Doppler:
  [I*1 unsigned integer 8 bits]
  Contains number of frame pairs used in rate calculation
  Range: 0 to 255

Signal Duration:
  [I*1 unsigned byte 8 bits]
  Range: 1 to 55

Signal Amplitude:
  [I*1 unsigned byte 8 bits] implied negative value in dB
  Range: −200 to −72

E/W and N/W Slope:
  [I*4 (Real+1)*8,388,608 unsigned integer 24 bits]
  Range: 0 to 16,777,215

E/W and N/W Intercept:
  Same as slope

E/W and N/S Variance:
  [I*1 unsigned byte 8 bits]
  High 4 bits contain -log 10 (calculated variance)
  Lower limit of 10^{-15}
  Lower 4 bits contain number of points used in angle fit

Time:
  (20 bits for time absolute value in milliseconds based on 10-min epochs),
  Range: 0 to 600,000

```
       Doppler Region
       <--->
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  !   !   !        !      Byte 2       !     Byte 1     !
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  <--->
  CPU Numbers
```

Doppler Region: Full = 01; Half = 10; Quarter = 11

CPU CPU A = 00, CPU B = 01

Table 4 — Text Data Field Arrangement

Bit Number	Byte Number	Quantity
32-79	4-9	Unused
80-87	10	Number of Points (Doppler)
88-95	11	Doppler Variance
96-119	12-14	Doppler Frequency
120-143	15-17	Doppler Rate
144-151	18	Signal Duration
152-159	19	Signal Amplitude
160-183	20-22	E/W Slope of Sine (Space Angle) vs Time
184-207	23-25	E/W Intercept of Sine (Space Angle) vs Time
208-215	26	E/W Variance of State (Space Angle) vs Time
216-239	27-29	N/S Slope of Sine (Space Angle) vs Time
240-263	30-32	N/S Intercept of Sine (Space Angle) vs Time
264-271	33	N/S Variance of Sine (Space Angle) vs Time
272-351	34-43	Time Stamp (epoch) of Observation
352-371	44-46	Adjusted Time Stamp of Observation
372-373	46	Doppler Region (Full, Half, Quarter Doppler)
374-375	46	CPU which produced the data for this frame

When no targets are available for transmission, the text and control field positions are replaced with housekeeping data. The latter message constitutes an idle message frame. It contains the data required to monitor subsystem functions, such as synchronous operation of the data transmission link, and indication of equipment failures. Two characteristics uniquely define the idle frame. The computer entry/access bit (in the synchronizing byte) is always set to zero. The bits in each text byte is a repetitive eight-bit sequence of a hexidecimal nine followed by a hexidecimal six. This bit pattern is called an idle byte. The repetitive idle byte enables the byte-oriented hardware in the subsystem to stabilize more quickly and reduces the initialization/resynchronizing time.

The message format contains 384 bits and is byte oriented. Byte orientation simplifies software programming of the field station equipment. The bit number and location (see Fig. 8) is shown below each field of the message frame. The first four bytes (0 through 3) constitute the leader framing bytes. The next 43 bytes (4 through 46) contain the test data fields. The trailer framing byte contains parity information. The first leader framing byte (byte 0) consists of five synchronizing bits, a line protocol bit (resend request), and a computer flag bit (computer entry/access). The second leader byte (byte 1) contains the message frame sequence number. Up to 256 consecutive message frames are uniquely identified by the sequence number. The third byte contains four control bits used by headquaters for command and control functions. The other four bits are unused. The software control byte (byte 3) is used in the field station software. The first six bits of the last byte (byte 47) are parity bits. They represent the low order sum of the number of "1s" contained in bit positions 8 through 375. The last two bits are unused; however, the time period they occupy is used in headquarters equipment for message assembly settling time.

Note that the data in each field are represented in integer mode for purposes of software programming. These representations take the form of unsigned 8-bit integers, unsigned 16-bit integers, signed 24-bit fixed point numbers, and unsigned 24-bit fractions. This use of integer mode simplified the task of software conversion at headquarters for the MRS. A second point should also be noted. Since the data transmission is byte oriented, and since the least significant bit of the least significant byte is transmitted first, the transmission of data fields must be reverse ordered at headquarters (in the ADDAS) before entry into the headquarters computer.

DATA TRANSMISSION LINE PROTOCOL

Line protocol is the process by which the data communications subsystem performs its operational functions. Three operational modes are provided for in the MRS. They are normal operation, error recovery, and initialization. During normal operation, idle frames are circulated through the data communications subsystem. The terminals at the field station and at headquarters use these frames to maintain line protocol functions such as synchronism, error checks, and system readiness. When the MRS flags the subsystem that it has completed processing data on a satellite, the subsystem completes assembly of the data into a target frame and transmits the target frame to headquarters. These target frames have priority over all other types of frames. Redundant transmission is used to increase the probability that the target frames arriving at headquarters are usable for final data processing and analysis. This redundancy is provided by two options. The option currently in use is a single repetition of each target frame. The second option is a target frame resend (retransmission) on request (ARQ). Although the latter option provides more efficient use of the data lines, the efficiency gained is insignificant to the present needs of data communications.

The data communication subsystem enters the error recovery mode when subsystem synchronism is lost. The loss of synchronism is characterized by an error in the synch byte and error detection by the parity byte. These errors are usually caused by equipment or data line failures. The most frequent failures are caused by malfunctions in the main power lines at the field stations (especially during thunderstorm activity) and switching breaks in the data line. When synch byte and parity byte errors are detected at either the field station or the headquarters ADDAS, the subsystem will revert to one or both of two submodes of operation. If synch byte and parity byte errors simultaneously occur in one or two successive target and/or idle frames, the subsystem begins a synch search of the message frames. Under this condition, the transmission of target frames is continued along with the transmission of idle frames. Subsystem synchronism is inertially maintained by subsystem hardware and software. However, if synch byte and parity byte errors simultaneously occur in three or more successive targets and/or idle frames, the subsystem will enter the resynchronizing mode. The field station and the ADDAS will both commence transmission of idle frames and the resynch bit will be set. If the failure exists for 1 s or more, the field station subsystem will transmit a time-out warning to the MRS video monitor. Meanwhile, both ends of the data line will be monitored for receipt of error-free idle frames. When error free transmission is resumed, the subsystem will begin the initialization process.

The initialization process is a two part procedure. It can occur after a data line failure and repair, an equipment failure and repair, or completion of an equipment installation. The first part of the procedure is lock up (synchronizing) of the headquarters ADDAS to the idle frames (with the resynch bit set) that are transmitted by the field station subsystem. After lock up, the ADDAS continues to transmit idle frames (with the resynch bit set). The second part of the procedure is to lock up the field station subsystem. The idle frames are searched for the synch and idle bytes. Since the subsystem is byte oriented, byte synch must be achieved initially. This byte synch usually occurs when two successive idle bytes have been detected. Byte synch then sets up the subsystem for frame synch. Frame synch lock usually occurs on the next following synch byte. Byte synch is checked on the next set of idle bytes, and final synch is achieved on the second following synch byte. If synch and parity errors occur during this procedure, the subsystem will return to the resynchronizing process. After final synch occurs, the field station subsystem resets the resynch bit (indicating field station lockup). When the ADDAS receives the idle frames with the resynch bit reset, it will reset the resynch bit in the idle

frames that it transmits. After the resynch bit has been reset in the idle frames that the field station receives, the subsystem transmits a send line recovery message to the MRS video monitor.

DATA TRANSMISSION MEDIUM

The operational performance required from the data transmission medium was based on three salient factors: full-time availability, throughput capacity, and long-haul (distance) capability. Full-time availability is a requirement of the NAVSPASUR mission. NAVSPASUR headquarters must have immediate access to all data and in real time as it is collected by a NAVSPASUR sensor (field station). The total collection and processing time for orbital detection, acquisition, and identification of the object must be small enough to enable a secondary radar system to acquire, track, and provide single pass ephemeral information on unknown orbiting objects. These unknowns are defined as objects for which ephemeris information is not listed in the NAVSPASUR satellite catalog. The accomplishment of this function requires that the data transmission channels be dedicated to the NAVSPASUR operation.

The throughput capacity is determined, in large measure, by the MRS performance specification. The MRS is capable of collecting and processing data on six simultaneously occurring targets (satellites and orbiting objects). The maximum time interval allowed for the transmission of data on these six targets to headquarters is 1 s. Each target message frame contains 384 binary bits of information and is transmitted twice by the data communications subsystem. The transmission of these data by the data transmission medium requires a minimum data transmissison rate of 4608 bits per second (384 bits per target frame times two target frames per target times six targets per second). The nearest commercially available rate is 4800 bits per second (bps). This latter rate provides for a transmission rate of 12.5 target frames per second (4800 bps/384 bits per frame).

A secondary concern related to the throughput capacity requirement was operational efficiency. A compromise was accepted by choosing a fixed frame length (384 bits per mesage frame), a synchronous mode of operation, and a fully duplexed communications channel. The choice of a fixed frame length eliminated the requirement to detect and compensate for variable frame lengths. The latter situation often requires the use of bit packing techniques and additional hardware and processing time. The choice of the synchronous mode minimizes the processing time for the maintenance of system operating protocol, since acquisition of each individual message frame is unnecessary. The choice of a full duplex channel provides a feedback loop for channel diagnostics and improves operational reliability.

A long-haul capability is required because of the long distances between NAVSPASUR headquarters and the field stations. These distances extend from approximately 805 km (500 mi) for the Ft. Stewart, Georgia, station to about 4830 km (3,000 mi) for the San Diego, California, station. The communication channel hardware that is used to transmit the data over these distances introduces distortions that degrade the quality of the received data. Two types of distortion that are peculiar to the NAVSPASUR data communication network are envelope delay (phase) distortion and attenuation distortion (amplitude response). As a result, the transmission medium must be conditioned to minimize the degradation in signal quality. In addition, this conditioning must be compatible with the data transmission requirements.

From the standpoint of operational cost and reliability, it was desirable to restrict the transmission medium to standard commercial voice channel widths of 4 kHz. The transmission rate of 4800 bps then requires an eight-state phase shift keyed modulation of a channel carrier at 1600 baud (Hertz rate). The use of C4 line conditioning limits the delay distortion to less than 312 μs (1/1600 bps $\times$ 1/2 = 312 μs/bit) in the channel frequency range from 1000 to 2600 Hz, and with frequency response flat from -2 to $+3$ dB.

A noise power budget was estimated to provide information on the bit error rate probability during system operation. The estimate is outlined in Table 5. A signal to noise (S/N) value of 9.5 dB (for phase-shift key (PSK) modulation) was used instead of 12 dB (for AM systems). This value provides an error rate of 1 bit in 10^5 bits. The estimated noise threshold would have to exceed -36.5 dBm_0 before an increase in the error rate would occur. This threshold provides a 6.5 dB margin above the CCITT (International Consultive Committee for Telephone and Telegraph) specified threshold of -43 dBm_0. The margin is more than sufficient to compensate for variations in line level input and frequency translation errors. This assumption was substantiated by test data collected on the Ft. Stewart, Georgia, and Silver Lake, Mississippi, field stations. An error of 18 bits per hour was a typical value recorded at these stations. This error translates into 1.79 error bits per 10^6 transmitted bits. This error rate is about five times less than the estimated error rate of 1 error bit per 10^5 transmitted bits.

Table 5 — Estimated Noise Power Budget
of the Transmission Medium

208A Specification line input signal level	-8.0 dBm_0
S/N for PSK systems	-9.5 dB
8 state PSK penalty	-6.0 dB
Envelope delay distortion penalty	-12.0 dB
Frequency translation error	-1.0 dB
Total estimated noise threshold	-36.5 dBm_0
CCITT noise floor	-43.0 dBm_0
Excess margin	6.5 dB

The requirements for the MRS data communication subsystem were satisfied by leasing standard telecommunications voice channels and operating these channels with the Bell System 208A Interface Specification. The leased channels are full duplex, C4-conditioned lines that are dedicated to the NAVSPASUR operation. The 208A Interface Specification fulfills the operating requirements of the 4800-bps transmission rate, automatic equalization, echo suppression inhibit, and interface compatibility.

REFERENCES

1. Handbook for NAVSPASUR System Orientation Volume 1, Section 4, Paragraph 2-4.2 through 2-4.3.

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